ON THE EXISTENCE OF ROSSI SECOND AND THIRD MAXIMA OF COSMIC-RAYS

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ABSTRACT. The controversial existence of Rossi second and third maxima of cosmic-rays were investigated in lead with a triple coincidence arrangements of counters under different geometrical conditions and definite evidences have been obtained about the existence of a second maximum at about 18 cm of lead and a third maximum at about 23 cm of lead. Except for a drop of coincidence frequency at about 20 cm, both these maxima might be considered as a single flat maximum starting from 16 cm and upto 24 cm similar to the results reported by Schopper and others. From a careful analysis of all the investigations made by other workers, it seems to the author that the failure of some eminent workers to confirm the existence of these higher maxima may be due to (*a*) firstly, overlapping by oblique showers when all the counters are placed very near the absorber and (*b*) much greater percentage of side showers of external and internal origin when all the three counters without appreciable vertical separation are placed too far below the absorber for narrow angle showers. An ideal arrangement, as follows from this investigation, is that one of the counters should be placed immediately below the absorber and the two others as far below the absorber as possible. Incidentally, it follows that a similar arrangement should be used in a counter controlled Wilson chamber for investigating penetrating showers.

For the interpretation of the origin of these higher maxima, from their correspondence with anomalies in RaC gamma-rays absorption in lead reported by the author, it seems that either there are some residual photons in RaC gamma-rays and in cosmic-rays which do not obey the current theories of photon interaction and behave like an unstable neutrino or that some such radiations are produced by photon in lead. Further, from the fact that RaC gamma-says are of maximum energy of only 2.4 Mev the author suggested that the new type of penetrating radiation may simply be a positron-electron dipole behaving as a neutral electro-meson before annihilation or being dissociated back to a positron and electron by Philips-Oppenheimer process. From energy consideration and the position of third maximum, it follows that such a dipole may have a maximum life of the order of 10^{-9} sec only.

INTRODUCTION

After the discovery by Rossi (1934) of the first maximum under about 2 cm of lead, a second maximum between 16 to 20 cm of lead was reported by certain workers, *viz.* Hummel (1934), Drigo (1934), Ackemann (1935), Clay, Gemert and Wiersma (1936) and others. Schmeiser and Bothe (1938) made an elaborate study of the second maximum and found that this maximum is prominent for narrow angle showers, being most prominent when an angle of 4° is subtended by the edge of the two lower counters

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at the centre of the absorbers and it is hardly noticeable for a divergence of more than 15°. By conducting the experiment in a cellar and under the open sky they concluded that the second maximum is due to the penetrating component of the cosmic rays, *e.g.*, meson. After the publication of this report by Schmeiser and Bothe, there has been a considerable controversy over the existence of this maximum. Morgan, and Nielsen (1939), although they got the Rossi second maximum using an arrangement similar to that of Bothe, failed to get it using four-fold coincidence of four counters in two vertical pairs. Dasgupta (1940) at Calcutta confirmed the result of Schmeiser and Bothe and obtained the second maximum under about 18.5 cm of lead. Altmann, Walker and Hess (1949) very carefully searched for these higher maxima using elaborate precaution. They at first, with a triple coincident arrangement, obtained some indication of two humps in the transition curve, one under about 13 cm and the other under 25 cm of lead absorber. The arrangement was such that one of the counter was immediately below the lead absorber and the two others at a distance of about 25 cm below the latter, the lower two counters subtending an angle of about 9.6° with the first one. But they did not get any hump in the transition curve when only coincidences between the two lower counters were recorded. All their experiments were carried out in a basement where the temperature varied between 20 to 27°C. Later, they repeated the experiment with an arrangement apparently identical with that of Schmeiser and Bothe but were puzzled at not getting any evidence on the presence of the second maximum. Similarly George, Janossy and McCaig (1942) using an arrangement similar to that of Hess and others failed to detect the Rossi second and higher maxima. These authors give a good summary of results and references of all the earlier investigations. Priebsch (1936) observed both second and a third maximum as early as 1936*.

Later, certain other workers, *viz.* Trumpy and Bergens (1939-40), Ozorai (1944) and M. Delta Corte (1946) reported the existence of Rossi second maximum under certain experimental conditions. The original journals not being available in India, only their summaries in Science Abstracts could be consulted. Trumpy and Bergens observed that when the counters were surrounded by lead, there was no second maximum but the latter appears when the counter system is surrounded by wood, etc. They conclude that this maximum is due to neutron in cosmic-rays. Ozorai, although he obtained Rossi second maximum for wide angle showers, showed that it disappears for narrow angle showers. Contrary to the findings of Schmeiser and Bothe, M. Delta Corte observed Rossi second maximum for two particle showers but not for 3 or more particles. In a Wilson chamber analysis Broussard and Graver (1941) obtained evidence in favour of second maximum

* The author is thankful to Professor W. Bothe for kindly pointing out this in a letter to the author.

of two particle shower. Similarly, Sinha (1943) with a counter controlled Wilson chamber obtained some evidence on the existence of Rossi second maximum. Mohr and Stafford (1944) using an ionisation chamber obtained a hump under about 20 cm of lead.

Recently, Clay (1949) claimed to have definitely established the existence of second maximum under about 16 cm of lead and a third maximum between 20 to 24 cm of lead. He further confirmed his results by repeating the experiment using gold and mercury absorbers under the assumption that the second maximum is produced by knock-on electron by meson. Fenyves and Haiman (1950) measuring only the vertical component, obtained evidence of a feeble maximum under 18.5 cm of lead and a third maximum under 26 cm of lead. The geometry of their experimental arrangement is not mentioned. Heyland and Duncanson (1951) have very recently contradicted the results of the above workers. But in their arrangements they have placed two counter trays in coincidence above the lead absorber and consequently such a system cannot detect any increase in coincedence rate due to the production of secondary showers in lead which is indicated by the absence of even the first maximum in their transition curve. Hence from this experiment, which simply measure the incident vertical component, one cannot say if the second or third maxima exists or not. Bothe and Thurn (1950) have again claimed to have definitely established the second and third maxima using very ingenious crossed counters arrangement over a large effective area and thus with a large coincidence frequency at the same time well-defined solid angle. They have selected by coincidence and anti-coincidence the showers produced by ionising or non-ionising radiation incident on the top of the absorber and from there conclude that the incident radiation producing second maximum is a single charged particle, whereas, the third maximum is produced by a long-lived neutral particle. The position of the third maximum, as found by these authors and also by Fenyves and Haiman (loc cit), is dependent on the barometric pressure. Mathov (1950) has also recently reported the existence of a second maximum at about 13 cm of lead which when corrected for the concrete roof amounts to about 18 cm of lead. Schopper, Höcker and Kulm (1951) using photographic emulsion have obtained definite evidence about the existence of a second maximum in lead starting from 15 cm and up to about 24 cm of lead.

The question arises why eminent experimental physicists like Hess and his collaborater, Janossy and his associates, could not detect these second and third maxima. The present writer, therefore, made a careful analysis of the different experimental arrangements used by these investigators and an attempt is made here to find out what may be the probable causes of their failure. It appears that (a) if such higher maxima exist at definite vertical thickness of the absorber, then unless the oblique showers generated in lead are eliminated, the maxima will be flat, if at all detectable, (b) if the three counters, in a triangular arrangements, are placed very close together and very near the bottom of the lead absorber, such a system will be equally sensitive to oblique showers as well to showers coming from the vertical direction. This is most prbably the reason why Hess, Janossy and their co-workers could not detect these higher maxima in some of their experimental arrangements. Moreover, Janossy and his co-workers in most of their experiments, used successive thickness of lead absorber in big steps. As for example, table 3 of their paper shows that after 10 cm of lead they next used 17 cm of lead absorber, to find out whether the second maximum exists assuming that after the first Rossi maximnm, the minimum is reached at 10 cm of lead. But this is not true, at least under certain experimental condition as is indicated in table 4 of their paper, recording their subsequent experiments. The results obtained by us also show that the minimum is not always reached at 10 cm of lead. To eliminate the effect of oblique showers, the counter system should be at a fair distance vertically below the absorber. But again if the counter sytem is shifted too far below, then it becomes more and more exposed to air showers and other side showers generated in the roof, etc., reaching the counter system other than through the lead absorber. But if one of the three counters is sufficiently separated vertically from the two others then it becomes sensitive only to vertical showers coming from the top absorber. These conditions are to some extent fulfilled in the arrangement used by Clay and very nicely fulfilled in the arrangement by Bothe and Thurn in their recent experiments except when they use anti-coincidence of the top counters for neutral radiations only. This is the reason why, as stated above, Hess and his co-wokers using an arrangement similar to that of Clay obtained some evidence of two humps at 13 and 25 cm of lead for triple coincidence arrangement, but not for double coincidence when the top counter was excluded. In the arrangements of Schmeiser and Bothe, as indicated by the scale of their diagram, the system of four counters in triple coincidence was placed at a distance about 30 to 40 cm below the absorber such that the two lower counters subtend an angle about 4° at centre of the bottom of the absorber. The two upper counters connected in parallel were shifted up by about 10 cm from the two lower counters. They used lead absorbers of two different dimensions, the first set of absorbers being of dimension 40×40 cm^2 and the top absorber being of dimension 61×61 cm^2. Janossy attributes the second maximum obtained by Schmeiser and Bothe to be due to first maximum at the edge of the protruding top absorber as he himself, by an apparently similar arrangement, could get a second maximum at about 14 cm of lead. But both Hess and Janossy placed the counter system at a much greater distance below the absorber in order that the edge of the lower counter subtend an angle of 4° at the centre of the bottom of the absorber, similar to that of Bothe and Schmeiser. This is probably due to the greater horizontal separation between the two lower counters. As indicated by the scale of their diagram, Hess placed the counter system at a distance about 100 cm and Janossy at a distance about 60 cm below the bottom of the absorber whereas, Schmeiser and Bothe placed the counter system only at a distance of about 30 to 40 cm. Moreover, in both Hess's and Janossy's arrangements the vertical separations of the top counters from the two lower counters was very small, particularly in that of Hess. As such, their arrangement of counters is more favourable for the detection of side showers of external origin and showers generated from the protruding position, if any, of the top absorber; both Hess and Janossy performed their experiments in basements with probably several stories above and as indicated by Janossy's data (loc. cit. Table 5) the number of background showers, due to air showers and the showers generated in the roof, etc., is more than the number of showers generated in lead absorber after about 10 cm of lead. Moreover, the result of present investigations by the author indicate that as the distance between the absorber and the lower counters is increased by keeping the upper counters in parallel immediately below the absorber, then the intensity of showers generated in lead and recorded falls of rapidly, following nearly an inverse square law from the bottom of the absorber. On the other hand, as the counter systems, close'y placed together, are shifted more and more below the absorber, more and more back ground showers pass through the counter system other than through the absorber, as the shielding effect of the top absorber becomes smaller and smaller; consequently at a large distance the percentage of shower, generated in lead will be small in comparison with the background shower ; so even if there is appreciable variation in the number of showers generated in lead, it will be hardly detectable in the total number of showers recorded. As stated above, Das Gupta in Calcutta obtained the Rossi second maximum, though he also placed the counter system at a distance about 80 cm below the absorber. This is due to the fact that in his arrangement, the two top counters in parallel at the top of the triangular arrangement were vertically separated from the two bottom counters by a large distance of about 20 cm. This gave a strong bias for recording only showers coming from the vertical direction. Incidentally, from this analysis as well as from the results of this investigation, it may be pointed out that to eliminate side and oblique showers, while investigating penetrating showers with a counter controlled Wilson chamber, the lower counters should be placed as far below the absorber and the Wilson chamber as is possible and another counter above the chamber and immediatly below the absorber.

In the light of the above analysis, to obtain further confirmation, we did our experiment more carefully and obtained definite evidence about the existence of two higher maxima.

Five counters of length about 20 cm and diameter about 3 cm were used in a triangular arrangement of three fold coincidence, three top counters in parallel were 'placed immediately below the top absorber and the two lower counters were placed at three different distances 10 cm, 25 cm and 66 cm vertically below the bottom of the absorber such that the angle subtended by the centres of the two lower counters at the centre of the bottom of the absorber were 22.5°, 9.1° and 3.4° respectively from these three distances. A lead sheet, one cm thick, was placed between the two lower counters in order to eliminate coincidences due to electrons knocked out from the counter wall. A vertical section of the experimental arrangement is shown in figure 1. The experiments were conducted in open air with a bamboo-mat shed constructed in the Bose Institute garden. The circuit diagram is shown in figure 2. The absorbers used were commercial lead sheets of dimension 12″ by 12″ and of two different thickness 1/8″ and 1/12″. Again, in order to detect

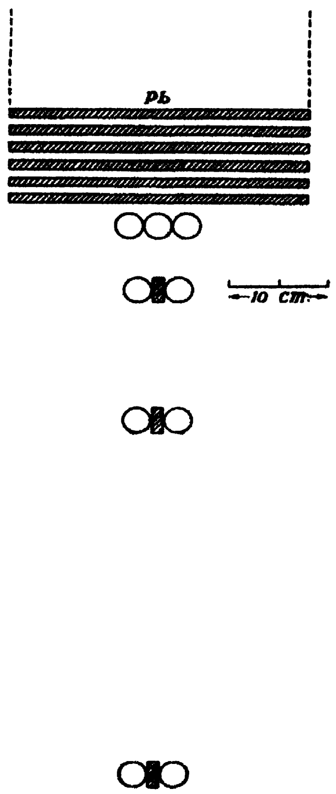

FIG. 1

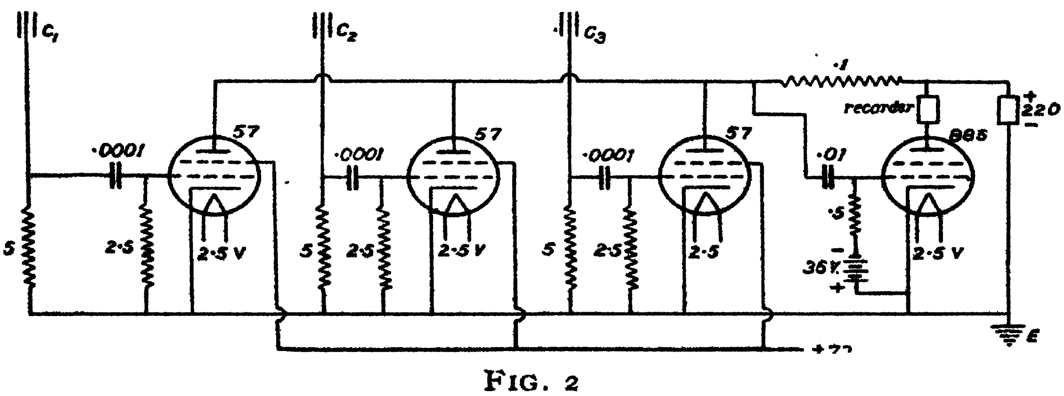

FIG. 2

(Resistances in M Ω and capacity in mFd. The grid-leak resistances are each 25 M Ω, and not 2.5 M Ω as shown in the diagram) any variation due to comparatively narrow angle showers at the same vertical distance 10 cm below the absorber, a second arrangement of the counters was used in which the two lower counters were brought together without any gap and the lead sheet in between them was removed. The angle subtended by the centres of the two counters at the centre of the bottom of the absorber is then 17°. The detecting arrangement used is a simple Rossi coincidence circuit, using one stage amplification with type 57 valve. Details of the circuit is similar to that given by Strong and others (1939). The resolving time was such that the accidental coincidence rate was less than the statistical error in all the experimental values obtained. In order to eliminate the effect of statistical fluctuations and other corrections due to temperature variation etc., the experiment under each geometry was repeated at different periods under nearly constant temperature and weather condition. Every day the data of this experiment were compared with those of a continuously recording pressure ionisation chamber set up in the Bose Research Institute, and any major variations in cosmic ray intensity, due to magnetic storm, Sunspot activity etc., when detected by both the experiments, were omitted when calculating the average frequency of coincidences. As a matter of fact, such occasional variation in cosmic ray intensity itself forms a very interesting field and the author with Chakraverty (Chaudhury

TABLE I

Thickness of Pb. absorber in cm	Expt. No. 1. (March, 1950)		Expt. No. 2. (April, 1950)		Expt. No. 3. (May, 1950)		Average results of three Experiments	
	Hours of observations	Average coincidences per hour	Hours of observations	Average coincidences per hour	Hours of observations	Average coincidences per hour	Total hours of observations	Mean average coincidences per hour
nil	6	15.1					6	15.1 ± 1.6
1.91	7	64 5					7	64.5 ± 3.0
8.25			6	19.5	4	18.0	10	18.75 ± 1.37
10.16	11	16.27	13	19.15	13	19.75	37	18.4 ± .71
12.1	12	17 3	12	20.75	12	21.5	36	19.85 ± .75
14.29	11	18.63	13	18.3	11	18.63	35	18.52 ± .73
16.2	12	17.17	13	16.84	14	18.07	39	17.36 ± .67
18.1	12	21.9	16	19.4	11	22.09	39	21.13 ± .74
20.0	12	19.08	13	19.0	12	18.66	37	18.91 ± .71
21.9	12	18.41	12	18.5	10	18.2	34	18.37 ± .74
23.8	19	19.9	11	20.2	14	18.07	44	19.39 ± .66
26.34	14	17.5	13	18.61			27	18.05 ± .82

TABLE II

Thickness of Pb absorber in cm	Expt. No. 1. July—August, 1950		Expt No. 2. Aug.—Sept. 1950		Average results of two experiments	
	Hours of observation	Average coincidence per hour	Hours of observation	Average coincidence per hour	Total hours of observations	Mean average coincidence per hour
nil	7	45.4			7	45.4 ±2.5
1.91	9	105 6			9	105.6 ±3.4
8.25	12	36.1			10	36.1 ±1.9
10.16	10	35.6			10	35.6 ±1.9
12.1	6	32.16	5	30.4	11	31.4 ±1.7
14.29	11	33.5	6	30.0	18	31.75 ±1.33
16.2	10	36.0	13	32.2	23	34 1 ±1.22
18.1	15	33.0	10	32.5	25	32 75 ±1.15
20.0	11	31.7	10	31.5	21	31.6 ±1.23
21.9	15	32.7	11	31.36	26	32.13 ±1.11
23.8	11	31.5	16	30.	27	30.75 ±1.07
25.07	13	34.1	23	34.1	36	34.1 ±0.97
26.34	18	31.8	25	29 84	43	30.82 ±0.85

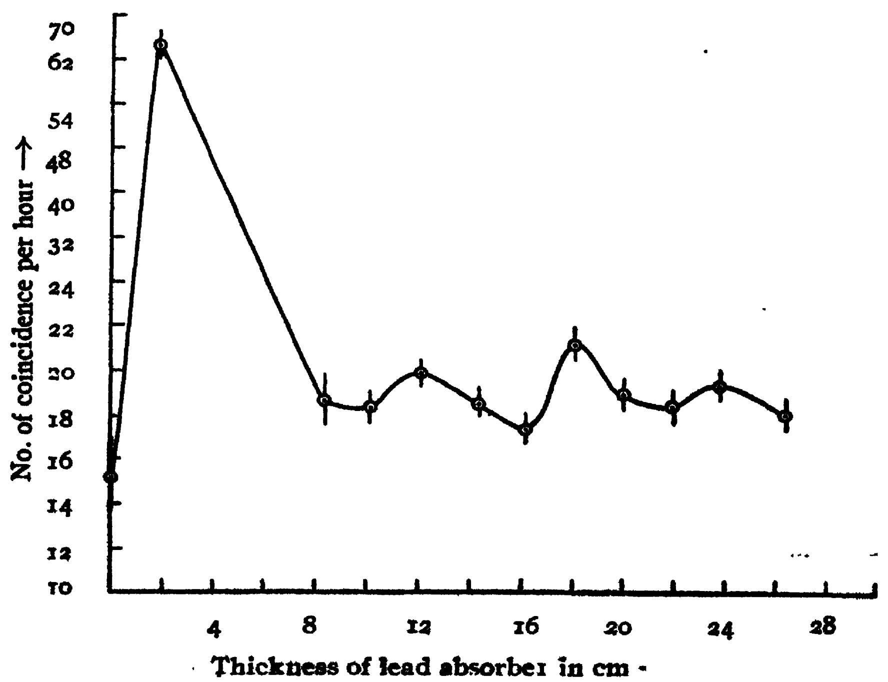

FIG. 3

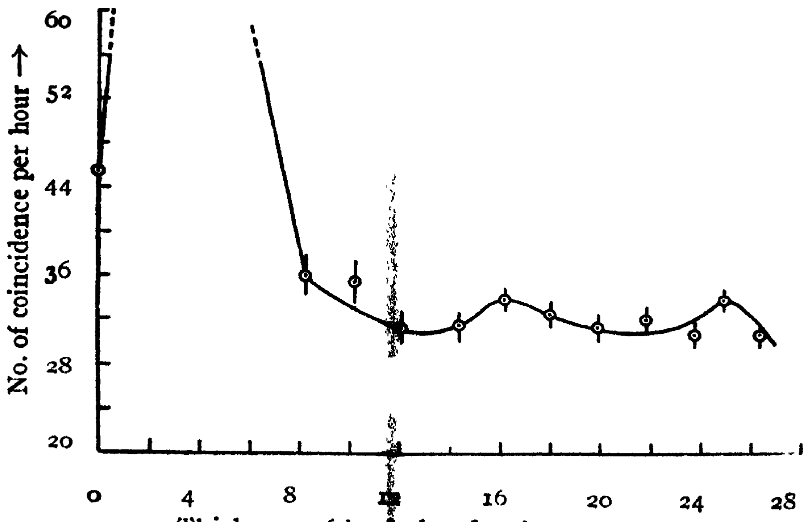

FIG. 4

TABLE III

Thickness of Pb absorber in cm	Expt. No. 1 Jan —Feb., 1951		Expt. No. 2 March—May, 1951		Total hours of obser-vations	Average frequency per hour
	Hours of observa-tion	Frequency per hour	Hours of observa-tion	Frequency per hour		
7.91	8	23.4			8	23.4 ±1.7
8.25	14	7.9			14	7.9 ± .75
10.1	17	7.7	8	5 12	25	6.87± .52
12.1	16	6.0	11	3.81	27	5.11± .44
14.29	16	4.1	16	4.38	32	4.24± .36
16.2	19	5.3	10	5.5	29	5.57± .43
18.1	16	5.4	19	5.94	35	5.69± .40
20.54	15	5.3	20	4.75	35	4.97± .38
23 03	13	5.5	14	5.14	27	5.32± .44
25.62	8	4.75	13	4 54	21	4.62± .47
29.0	33	4 61			33	4.61± .37

and Chakraverty, 1950) published a note on one of such variation when the intensity increased by about cent per cent. The experimental data under two different geometry are represented in Table I and Table II and the average shower frequency plotted against absorber thicknesses are shown in figure 3, and figure 4. Since the coincidence rate without the 1 cm lead between the two lower counters became nearly double that of the lead

TABLE IV

(June, 1951)

Thickness of Pb absorber	Hours of observations	Average frequency per hour
1.91 cm	16	5.88 ± .61
10.10 ,,	16	0.50 ± .18
14.29 ,,	16	1.0 ± .25
16.2 ,,	16	1.13 ± .27
18.0 ,,	20	1.8 ± .30
20.22 ,,	14	57 ± .20
23.03 ,,	16	1.13 ± .27
25.62 ,,	14	.14 ± 10
27.30 ,,	8	.25 ± .18

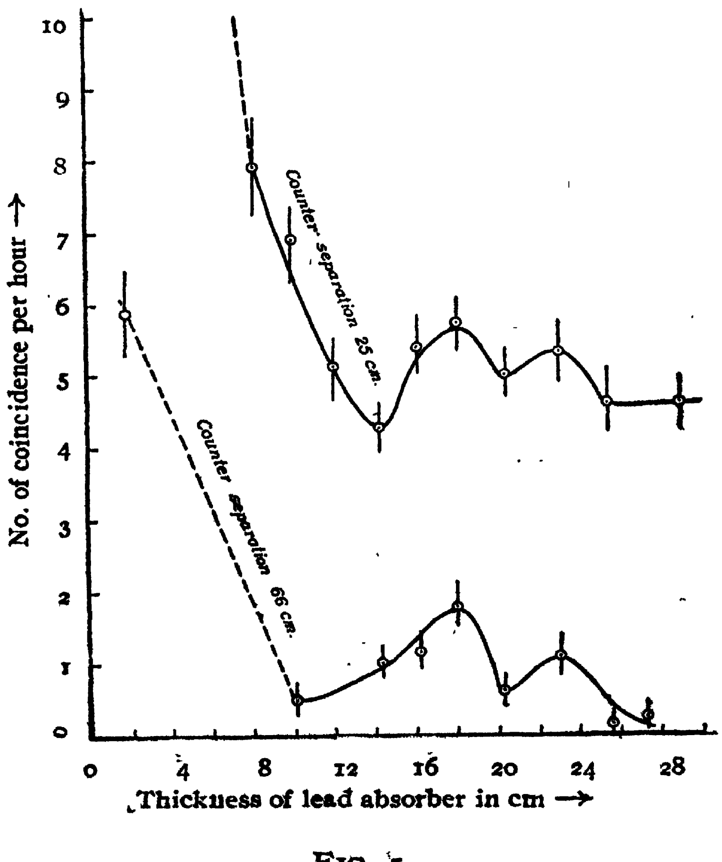

FIG. 5

sheet as shown in Table II, therefore it was suspected that so much difference might be partly due to spurious coincidences due to a single particle which simply knocks out an electron from the counter wall which passes through and excites the other counter. So the two subsequent experiments with the two lower counters at 25 cm and 66 cm below the absorber, were done only with the lead sheet between the counters so that no knock-on electron can pass through it. The experimental results are shown in Table III and Table IV and in the average shower frequency are plotted in figure 5.

RESULTS AND DISCUSSIONS

Table I and the curve plotted in figure 3 show that after the prominent first maximum there is definitely a second maximum at about 18 cm of lead supported by each of the three separate experiments. But in addition, there are some evidences of two less prominent maxima at about 24 and 12 cm of lead. The shape of the transition curve is rather complex in this position. When the two lower counters were brought very near and the 1 cm thick lead sheet between them eliminated, then, as stated above, there is an appreciable increase in the frequency of shower which may be partly due to such an arrangement being more sensitive to recording oblique showers and knock-on showers. Such an arrangement is also more sensitive to slightly narrow angle showers. The results in Table II and the curve plotted in figure 4 show that the second maximum has shifted to about 16 cm of lead but there is a definite third maximum at about 25 cm of lead. The slight shifting of the second maximum in this case might be due to greater predominance of oblique showers travelling a greater oblique distance than the vertical.

Tables III and IV and the corresponding transition curves plotted in figure 5 also shows that after the first maximum, there is definitely a second maximum at about 18 cm and a third maximum at about 23 cm of lead. Except for one point under 20 cm of lead, we might consider the second and third maxima to be a single rather flat maximum between 16 and 26 cm of lead exactly similar to the shape of the transition curve obtained by Schopper and other (*loc. cit.*). But in both the experiments we found the coincidence rate under 20 cm to be much less than that under 18 and 23 cm of Pb absorber. Further, as shown in the last curve (two lower counters at a distance 65 cm below), the second and third maxima are very prominent when the counters subtend an angle 3.4° at the centre of the bottom of the absorber. This is in agreement with Bothe and Thurn (*loc. cit.*). But this may be either due to the pair of particle responsible for these maximum are initially emitted with a very narrow angle or it may also be at least partly due to complete elimination of oblique and side showers. In our curves both the second and third maxima are much sharper than those of Bothe and Thurn who have obtained a flat-second maximum. But this may be due to large effective area of the crossed counters used by them so that the pair of particles may come from appreciably oblique direction. Another interesting fact of our investigation is that after the third maximum at about 23 cm of lead there is an abrupt drop of coincidence frequency. A similar sudden drop in meson absorption has been reported by Aiya (1944) and Gill (1950).

From these experiments it can be definitely concluded that there is a second maximum of cosmic rays between 16 and 18 cm and a third maximum between 23 and 25 cm of lead. It should, however, be mentioned that since the old commercial lead sheets were used as absorber and since all the lead sheets are not exactly of uniform thickness, therefore, there may be an uncertainty of about 1 cm in the exact position of these maxima.

Now for the interpretation and origin of these higher maxima, various conclusions have been made by different workers. Schmeiser and Bothe from the experiments in open air and in a underground cellar, concluded that the second maximum must be due to a meson. But even in underground cellar there will always be present equilibrium amount of decay and knock-on electron associated with meson. Bothe and Thurn further confirm their previous conclusion by their recent experiments. The *C*-curve of their results showing only the second maximum is due to showers produced by a single charged particle. But in this curve both the first and the third maximum are absent. It is not clear why there should not be the first maximum in the *C*-curve. The *d*-curve of their results showing only the third maximum is due to a non-ionising radiation incident on the top. From a comparison of *C*-and *d*-curves they conclude that the second maximum is only produced by a single charged particle, probably a π-meson dissociating into a μ-meson pair according to the process recently suggested by Wentzel (1050). The third maximum they believe to be produced by a long lived neutretto. But it is not clear how can a hard μ-meson pair produced by Wentzel's process get so easily absorbed within a few cm of lead after producing the second maximum. If the μ-meson pair are very soft then these will suffer so much multiple scattering while passing through the lead absorber that there will hardly be any chance of recording them in a narrow angle. Moreover, since both the first maximum and the third maximum are absent in the *C*-curves, therefore from their experiments one may not conclude that the third maximum cannot be produced by a single charged and energetic electron or positron which also produce the first maximum. In fact, there may be some genetic connection between the first and the third maximum. The non-ionising radiation producing the third maximum may also be an energetic photon. Schopper and others state that the stars responsible for these maxima resemble the stars produced by photon cascades. Clay believes that the second maximum is due to knock-on electron shower produced by a meson. His data shows that the second maximum is more prominent for showers of low intensity and not necessarily a shower of two particles with narrow angular divergence. If the secondary radiation producing the higher maxima consists of photons of low energy, then of course the probability of recording threefold coincidence is decreased by a factor of the order 10^{-2} to that of two-fold coincidences and in that case some of the cloud chamber and other evidence of the second maximum to be due to two particle showers,, may be simply due to Compton electron instead of a meson pair. Trumpy and Bergens, who obtained the second maximum only when the counters were surrounded by wood, etc. and not when surrounded by lead, concluded that the second maximum is due to neutron. Similarly to interpret the results of Nielsen and Morgan, who obtained second maximum using a triple coincidence arrangement similar to Bothe and Schmeiser but failed to detect it using four-fold coincidence in two vertical pairs, it must be assumed that secondaries are soft radiation of low intensity. But we understand that Bothe and Thurn placed lead absorber a little above the crossed counters to study the nature of secondary radiation responsible for the second maximum and they found some residual effect even after 10 cm of the absorber. But there may be some difficulty in this conclusion due to the formation of third maximum and also if the secondary radiations are produced by a neutral particle with a life such that it decays or is annihilated at a distance just above the crossed counters then the absorber will have no effect on it.

From all these it appears that the origin of these higher maxima and the nature of the secondary raditions are not yet clearly explained. But we were led to these investigations due to the correspondence of these higher maxima with anomalies in RaC gamma ray absorption in lead reported by the author (Sen Choudhury 1948, 1950 and 1951). Particularly the abnormally low value of the absorption co-efficient of RaC gamma-rays in lead, as shown in figure 6 between 22 and 25 cm of lead is almost in exact coincidence with the third maximum obtained under these investigations and by Bothe and Thurn in their d-curve. The experimental value of the absorption co-

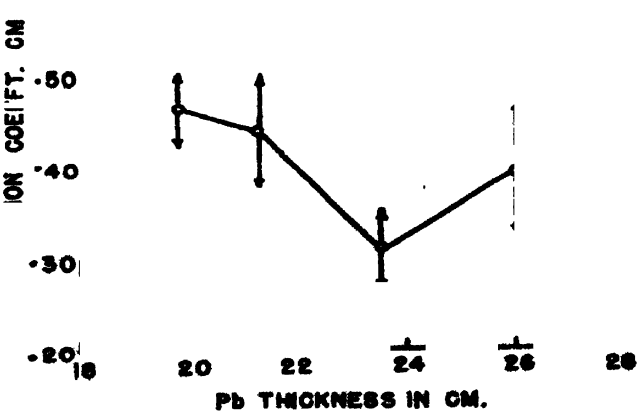

FIG. 6

efficient in this region is far behind the theoretical minimum value about .47 cm^{-1} for photons of all energy as calculated by Heitler (1944). The experimental values of absorption co-efficient at about 20 cm of lead is in agreement with the theoretical value. Some peculiarities in absorption were also observed at about 16 cm of lead. Soddy and Russell (1910), about 40 years back, actually obtained a hump in the log intensity curve exactly in the region where Rossi second maximum is obtained. They interpreted this to be due to some, peculiar secondary radiation generated in lead and manifesting itself in this locality. They could eliminate it by bringing the electroscope very near the Radon source. Now, unless these correspondences are purely accidental, it is very likely that the higher maxima, particularly the third maximum in Rossi curve and the anomalies in RaC gamma-ray absorption have the same origin. In this case we must conclude that either there are some residual photons in RaC gamma-rays and in cosmic-rays which do not obey the current theory of photon-interaction with matter and resemble neutrino-type of radiation which is unstable or some such radiation is generated by photon in lead. Again in order to explain the dependence of the position of Rossi higher maxima on the absorber, we must assume that, however small, these radiations must have some continuous interaction with the material of the absorber before being transformed into a counter-detectable radiation. From this as well as from the fact that RaC gamma-rays are of maximum energy only 2.4 Mev, the author suggested that this radiations may be purely due to a positron-electron dipole behaving as a neutral electro-meson before annihilation. Such a dipole may again dissociate back to a positron and an electron by Phillip-Oppenheimer process in the strong nuclear field of lead. According to Wheeler (1946), such a system can only form hydrogen-like atom with parallel spin and a life of about 10^{-6} sec against annihilation. The probability of their direct formation is one in million. Deutsch (1951) obtained experimental evidence of the formation of such system called positronium in abundance. But as a hydrogen-like atom of dimension about 10^{-8} cm such a system has very little penetrating power as a neutral particle unless the positron and electron are much closer together like a dipole. According to Heitler (1944), again the probability of a positron capturing an electron is maximum when its kinetic energy is .5 Mev. So a positron-electron dipole with very slight interaction in lead and with this much energy requires a maximum life of about 10^{-9} sec to produce the anomalies the dependence on spin may be responsible for the two groups of slightly different life.

Further, in this connection a reference may be made to certain experiments performed by some Chicago physicists. Gerhart Groetzinger, Kruger and Lloyd Smith (1945) obtained some excess of counting near a cyclotron with counters arranged in coincidence and shielded by more than 19 cm of lead absorber. They interpreted these to be due to artificial production of meson of low mass intermediate to that of a meson and an electron. The production cross-sections are similar to that for bremsstrahlung. But they (*loc.cit.* 1947) could not confirm their hypothesis by their subsequent cloud chamber analysis. Broadbent and Janossy (1949) concluded that the particles responsible for some penetrating showers are not mesons but some other particles produced according to a Z^2 law. It is not unlikely that these phenomena, the anomalous absorption of photon and the two higher cosmic-ray maxima have the same origin. All these may be satisfactorily explained by the above hypothesis of a positron electron dipole behaving as a neutral electro-meson before annihilation and with very small interaction with matter. Recently, Steinberg, Panofsky and Steller (1950) with Berkely cyclotron have definitely established the production of neutral meson along with charged meson by photon. But since the life of such a meson is found to be only about 10^{-13} sec, therefore, such a neutral meson either produced by photon or knocked out from a nucleus by proton cannot explain the two Rossi higher maxima. It may, therefore, be posible that by similar mechanism neutral electro-meson, with properties described above and with longer life, can be directly or indirectly produced by less energetic photon along with positron and electron. For further elucidation we may try to repeat this investigation with a counter-controlled Wilson chamber.

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